SAO x Mahouka
Versus II

"Hey, Onii-chan, what's a quantum *computer*?"

——How many big brothers could there really be in this world who could give an adequate answer smoothly and on the spot, after being asked such a question by their high school first year imouto-san who neither excelled in Mathematics nor Physics, and in the first place, probably had little understanding even about the structure of a Neumann-type *computer*?

At the very least, I'm not such a *super* onii-sama, so I *hovered* the fava beans over the table after just having stabbed my fork into them, and hummed for a moment.

"Hmmmmmm"

At that moment, my imouto-san gave an expression of being sorry from the bottom of her heart, and lightly lowered her head.

"Ah, sorry, there are things that even you don't know, Onii-chan, right? I shouldn't be asking you all the time, and should try looking it up myself once in a while."

It's tough being in the position of an ≪Onii-chan≫, as I couldn't obediently back down now that she said that. While the fava beans were still suspended, I cleared my throat with an 'ahem'.

"No, well, that's not it, I'll explain it to you if a rough explanation is enough."

"Yeah!"

Nodding energetically, my sister, Kirigaya Suguha, smiled innocently.

Our mother, who worked as a *digital*-type news magazine editor, would almost certainly not wake up, so, for Saturday and Sunday breakfast, Suguha and I have grown accustomed to prepare enough for three, but eat with just the two of us. Today's *menu* is an easy to make risotto with canned *white sauce*, a *salad* of *romaine lettuce*, *cauliflower* and fava beans, *fresh blueberry yoghurt* and cafe au lait with plenty of *milk*.

After sending the fava beans into my mouth with my right hand, I first began talking to clear the path.

"Ehm, first of all, on what a quantum is……"

"I know that much. It's an elementary particle! Like an atom, or electron."

Without a moment's delay, I found fault with what Suguha had said in a flash.

"Vuvu[1]——. That's a double mistake."

"Wha, where?"

"First of all, an atom isn't an elementary particle. Because an atom is made of protons, neutrons and electrons."

"Then, those three are elementary particles?"

"Vuvuvu—— Older textbooks may describe it that way, but right now, out of those three, only electrons remain as elementary particles. This is because protons and neutrons were discovered to be formed from even smaller grains called ≪*quarks*≫. In other words, *quarks* became elementary particles."

[1] The buzzer sound effect often made during quiz shows when someone incorrectly answers a question.

After adding 'at least, for the time being' in my mind, I pointed out the second mistake.

"And also, quanta aren't *equal* to elementary particles."

"Wha……?"

"'Elementary particle' is an expression that indicates ≪existence≫, but 'quantum' is a word that should indicate ≪state≫……"

"Whaa……?"

By this point, a small-*size question mark* already hung above Suguha's head, so I quickly commented on it.

"I-in other words, elementary particles are the smallest units of ≪material≫, and quanta are the smallest unit of ≪physical quantity≫……"

Suguha's question mark grew middle-*sized*. If she's stumbling at this point, then there's no way we'll get to quantum *computers*.

"A-alright, I'll explain it with an analogy. This risotto is around two hundred…… no three hundred *kilocalories*, right?"

After I said that, Suguha nodded, although making a slightly unpleasant expression.

"Then this rice grain of the risotto is an elementary particle that cannot be decomposed any further and it should only yield 0.001 *kilocalorie*…… in other words, one *calorie*, right?"

"Hm, that's impossible. If I'm not mistaken, we've learnt that a full rice has around three thousand grains, so if we assume that there are that many grains, a single grain has three hundred divided by three thousand, 0.1 *kilocalories*…… A hundred *calories*, right? To get one calorie,

you have to divide a rice grain into a hundred pieces."

"But, since it's an elementary particle, you can't do that. In other words, the calorie, no, energy of this risotto can only be represented as rice grains…… having the value of a hundred calories apiece scattered here and there. Consider the concept that the smallest amount of this energy is a quantum."

"Hmm…… it's like I get it, and don't get it……"

Suguha still made a vague expression, but I didn't know how long it would take if we got stuck here, so I had to force my way through.

"Well, in practice, you can split a rice grain into as many parts as you like, but in the case of, for example, electric energy, the smallest unit is an electron and it absolutely cannot be divided, so an electron in this case is a quantum. Light energy also has a smallest unit, and that's a photon. That's also a quantum. In other words, a quantum is a way to refer to elementary particles through focusing on their ≪cannot be divided any further≫ property……though I wonder if its fine if I say it like that."

"Uh huh."

This time having seemingly grasped it one way or another, Suguha put a single rice grain on the tip of her spoon and sucked it up with her puckered-up mouth.

"Then, a quantum isn't an ***object***, but rather a unit, right?"

Although I felt that it was still impossible to agree when asked in that manner, but I decided to say 'yeah' despite her minor error, and nodded.

"Yeah, well, it's fine to think like that for now. So, we've finally returned to the beginning…… A quantum *computer* is, exactly that! a *computer* that uses quanta!"

“‘Ta-dah’, finishing my sentence while making such a flashy SE[2] in my heart, I moistened my throat with my cafe au lait, for a while sighing in relief that this ended without problems. However.

"Hey——you——know! That much, anyone can figure out! It’s like when somebody asked you ‘what’s a ≪kirikaeshi gosuku≫[3]’, you’d answer ‘it’s the five rules when performing kirikaeshi’!

After she immediately replied like that, I fixedly stared at the face of my sister who was a member of a kendo club. Indeed, kirigaeshigosoku or something seemed to be kendo terminology; I didn’t understand anything other than that.

"……I-I’m sorry. Then, I shall continue……"

“Uh-huh, no objection.”

“……”

After stuffing my cheeks with a spoonful of *cream* risotto with cheese for the sake of replenishing my energy, I considered the way I would handle the more difficult problem. Firstly, I undoubtedly had to start with this huh.

“Err, Suguha-san. Concerning the *computer* we usually use, the so called Neumann-type….. an explanation is needed…… right?”

“What’s that?”

“It is needed, huh.”

Preparing for a long explanation, I once again cleared my throat.

[2] The abbreviation for “sound effect”.

[3] Kirikaeshi (切り返えし, lit. “cutting repeatedly”) is the name of a kendo exercise that involves a succession of strikes. Gosoku (五則) literally means “five rules”.

"Err, well, simply put, a Neumann-type is the arithmetics of just 0s and 1s…… In other words, operated by binary digits. The information represented by one set of 0s and 1s is 1 *bit*. If it becomes eight sets, then it's 8 *bits*. The cutting edge 128-*bit* CPU can process one hundred and twenty eight sets of 0s and 1s at the same time."

"Hmm…… And is that amazing?"

"It is! There are only two ways that you can express 0s and 1s with 1 *bit*. If it's 2 *bits*, there are four ways: 00, 01, 10, 11; if we convert that to the decimal system, it would be 0, 1, 2 and 3. Then, if we have 4 *bits*, how many ways can it be expressed in?"

"Eight…… no wait! Err…… If we take that 2 *bits* has four ways, 3 *bits* has eight ways, then 4 *bits* has sixteen ways?

"Oh, correct. In other word, the numbers that can be handled with a 4 *bit* CPU are 0-15."

"Hmmm. When those *bits* increase, something good happens?"

Being asked this question with a serious look, I couldn't answer right away. There should be a lot of great things about it, but when it comes to giving an example that even Suguha could understand……

"Well, for example, if we take an old 32 *bit* OS, then its *memory* could only use 4 *gigabytes* at max, but if it was a 64 bit OS, in theory, it could use 16 *exabytes*, or 17,2 hundred million *gigabytes*……"

"Whaa, an old *personal computer* only had 4 *giga* worth of *memory*? Even though an *AmuSphere* has many times more..."

"S-see, *bits* increasing is a good thing, right?"

One way or another, I seem to have conveyed the idea to her, so, after I drank a mouthful of cafe au lait, I returned to the flow of the

conversation.

"……Well then, let's count it again, how many ways can the number handled by with 128 *bits* be expressed in?"

"Hm-err…… s-since it multiplies by two, 5 *bits* has thirty two ways, 6 *bits* has sixty four ways, 7 *bits* has one hundred and twenty eight ways, 8 *bits* has two hundred and fifty six ways…… I can't do it up to 128 with mental arithmetics at this rate!"

"Yeah, I can't do it either. In other words, it's 2 to the power of 128, so let's see…"

As expected, there was no way I could handle such a number with mental arithmetics, so I tried calculating it with the portable terminal left on the *table*.

"Let's see……340282366920938463463374607431768211456 ways, it seems. Thirty nine digits, huh…… What would be the highest denomination in kanji numbers to express this……? Ten hundred thousand man[4]……."

"I don't know such a thing, let's just leave it as a super huge number! I mean…… if even a current *personal computer* is capable of performing such an unthinkable number of calculations, then there's no need for a quantum *computer* already!"

I hastily stopped my imouto-san who, with just a single stroke, cut down the dream *machine* that scientists from all over the world were researching with their utmost effort.

"W-wait wait. Even such an amazing 128 *bit* CPU is poor at some things."

"……Like what?"

[4] A man (万) is a Japanese number for 10,000. Since Kazuto is talking about how to express the number in kanji and there's already a thousand before the man, I decided to leave it untranslated.

"For example, prime factor decomposition."

Hearing that, Suguha made an expression that said 'what's that?'"

"That's what you learn at middle school, isn't it? It's expressing integers as their composite prime numbers, right? I don't recall it being very troublesome though."

"Oh, now you've said it. Then, how about trying to decompose 33 into prime numbers?"

"Let's see, it cannot be divided by two, then if we divide it by 3, we get 11…… that's a prime number, so that's already the end. The answer is 3 X 11."

"Correct. Then……"

"How about decomposing 7663 into prime factors?"

"Uii!?"

Making a strange sound, Suguha wrinkled her forehead, and after thinking about it, began fiddling with her own portable terminal.

"By 3…… indivisible, 5 is obviously not going to do, 7…… also won't do, 11 too, 13 too, errr, now what was the next prime number……"

"See, it isn't that simple, is it? By the way, the answer to the current problem is 79 X 97. Asking the question is easy, but it can only be divided into two largish prime numbers."

"Ugh, I suppose I get the point…… Ah, but, if you use a *computer*, it would take like a moment with current calculations, right? It could just divide 7663 by prime numbers in turn and provide an answer if it goes all the way to 79."

"Yeah, something like that. With this amount of numbers, it wouldn't even take a tenth of a second. However, prime numbers go on infinitely. As the numeral digits become bigger, the time it takes for decomposition increases exponentially. Prime factor decomposition is utilised for the 《RSA cryptosystem》 that even assists us on the *net*, but, if you decide to decompose the currently used 2048 *bit*—…… in other words, a six hundred and seventeen digit — key into prime numbers using a Neumann-type *computer*, it is possible that it could even take ten years or more, even with the fastest-grade computer in the world."

"Te-TEN YEARS!?…… You mean that even Yui-chan would take that long?"

The moment I heard Suguha's question, despite this being the real world, I ended up quickly looking around the vicinity.

Luckily, my beloved daughter, *top down*-type AI Yui didn't seem to hear it, so I breathed out in relief.

"Hey, don't speak about Yui like that! Knowing her, she'd probably say something like 『I'll try it!』 and not return for ten years."

"Ahaha, that seems likely."

Looking at Suguha laughing carefreely, I sighed. I then threw the quantised *cream* risotto into my mouth and put my thoughts in order while chewing the food.

"So, well, there are things that even current *computers* are bad at. ——But, if a quantum *computer* is used, it could finish the prime factor decomposition of even large numbers in the blink of an eye…… probably. This *equals* that if it's used around the world now, ciphers that appear to be completely safe would end up being broken quickly."

"Hmmm…… Then, how is it that a quantum *computer* can decompose

them quickly?"

As I thought, I'll have to explain that too huh, and with that I unintentionally closed my eyes. To be honest, I don't have the confidence that I myself truly understand 'how' is it capable of that.

However, if I end up *giving up* here, then what would be the point of all the strenuous effort up till now, so I gave my go at the *challenge* that was becoming reckless.

"Well, I did explain about quanta in the very beginning."

"Yeah. They are the grains that cannot be divided any further."

"……W-well, that's right. So, since quanta are awfully small, a lot of strange things occur. One of them is something called a ≪superposition state≫…… for example, if you try to close an atom in a small box. That atom could be spinning in either a clockwise rotation, or a counter-clockwise rotation, but that's not decided until observation. It's not that it's unknown, it's undecided. It's a state when both clockwise and counter-clockwise *spins* overlap."

"Whaa?"

Suguha said, while making a 'what's this guy saying' expression with her eyes.

"Then just decide which one is it! If you open the box, you'll know right away!"

"Funny you should mention that, since atoms are super tiny, once you open the box, their oscillation, rotation and the like will change. Bluntly put, as for why a genuine quantum *computer* doesn't exist in reality at present, I think that a big part of the reason is because it's difficult to measure atoms…… in other words, their quantum state, accurately."

“Hmm……”

Although still finding it difficult to understand, Suguha nodded.

“……So, if the atom's rotation overlaps, something good happens?”

“Yes. For example, if we take that a right rotation state is 0, and a left rotation state is 1, then one atom can have the information of 1 *bit* but…… overlapping *spins* means that a state of both 0 and 1 can be created. This is called a quantum *bit* or *qubit*, but what’s important is that, in contrast to existing-type *computers* that can basically only calculate one number at a time, a quantum *computer* using quantum *bits* can calculate numerous numbers at the same time. Anyway, as you can see, it’s because they overlap.”

“Whaaa?”

“I understand the feelings behind you wanting to say that very well, Sugu. But, right now, please swallow it like that!”

Having just stuffed her cheeks with fava beans, Suguha's expression was difficult to read as she halted her mouth, but, before long, she swallowed the beans with a gulp while mumbling.

“All right, I’ll begin with the parts that I understand…… So, that is, we make a quantum *computer* by lining up two thousand and forty eight atoms that can spin either clockwise or counter-clockwise. With that, we enter a 2048 *bit*…… in other words, a six hundred and seventeen digit super huge number that I mentioned earlier, and then decompose it into prime factors. And then the quantum *computer* could perform the prime number divisions at the same time using the superposition state, completing the calculation in a mere moment, despite that it would take an existing *computer* tens of years. Well, what do you think, isn’t that amazing!”

Suguha threw a glance at me, who had tried to overcome the problem

somehow with a lot of effort, with upturned eyes and said a short, merciless comment.

"Onii-chan, sorry. As for the second half, I completely don't understand what you are saying."

Part 2

"……And that's how it went. Don't you think she was mean, Higa-san?"

Listening to my drawn-out and continuous idle complaint, for some reason the researcher with pointed *hair*, roughly round glasses and wearing a T-*shirt* with a *retro game logo* made a bitter expression and answered.

"What are you saying-s[5], Kirigaya-kun. Being able to tell your imouto-chan, a first-year highschooler, about quantum *computers* is an extremely *rare event*, it normally doesn't happen so soon-s! If your imouto-chan had raised a 'that's wonderful' *flag*, then she would likely have developed an awakening to quantum mechanics, and would be asking for employment in *Rath* in the near future."

"No way, absolutely not."

While giving a resolute reply, I looked around the broad room.

For some reason, the room in a *building* in Roppongi's Tokyo *midtown*, in other words, not far from Camp Hinokicho that belonged to the former Japan Defence Agency, was fully cramped with machinery, with countless cooling *fans* roaring.

The object that I sat on was a *gel bed* attached to a noticeably large machine. Its exterior was made from *aluminium* which gave off a dull light; the name of the machine, which was so big that it could be called

[5] Higa Takeru has a habit of shortening the copula です (desu) to ッス (ssu).

the lord of the room, was ≪*Soul Translator*≫. A machine that translates the soul; such an exaggerated *naming* was by no means ostentatious.

That is because this device is a fourth generation-type *FullDive machine* that *entangles* with the light quanta that comprise the human consciousness, and makes it possible to communicate with the soul itself.

And so, in a sense, it can be called the world's leading quantum *computer*.

While preparing for the *dive*, an idea struck my mind, and I asked the pointy-*haired* researcher, Higa Takeru, a question.

"Come to think of it, Higa-san, can this STL perform a 2048 *bit* prime factor decomposition?"

"W-what's-s with that question out of the blue? It can't-s, as the controller's quantum *register* is completely insufficient-s."

"Then, would it be possible if the *register* was expanded?"

"W-well that would…… No no, I won't have this conversation-s! Some time ago, I received a severe scolding from Kiku-san after he discovered that I had tried to expand the *register* in order to *get* the prize for the RSA deciphering *contest*, so it's absolutely not going to happen-s!"

"……U-understood."

"More importantly, are you all set? I'd like to begin the test soon-s."

"OK-s"

Nodding, I eased my body onto the *gel bed*. Overhead, a *headgear*-type *interface* which completely covered the head slowly descended.

The reason why I haven't told Suguha about this ≪quantum computer≫ is that she would definitely have a 「I also wanna go!」 tantrum once I

told her. However, I was sufficient for this suspicious 'live-person test" part-time job that wasted a long awaited sunday.

Anyway, the last time I did this part-time job, I actually experienced something strange.

Having *dived* into an abandoned city who-knows-where instead of a VR *space* meant for a *test*, I fought against a silver avatar calling himself ≪*Silver Crow*≫. The result was a draw, or rather the connection was cut before a conclusion could be reached. But, despite thinking thoroughly about it, I still couldn't come up with an answer to the question of what that experiment was.

However, I had my own guesses on that matter.

I haven't told this to Suguha either, but the reason for the event could be that since quantum *computers* can process several calculations at the same time, countless quantum registers existing in parallel worlds could also be used——There were such discussions that were treated as jokes.

At that time, could I have ended up connecting with the same kind of *device* existing in a parallel world, or maybe the future? And then fought against ≪*Silver Crow*≫ who was using that *device*……?

As a matter of fact, it all sounded like a dream. No, it may really have been a dream.

At the very least, I can't verify the phenomenon anymore. That's because such an event probably wouldn't occur twice.

"Well then, I'm starting the the connection-s."

Hearing Higa's tensionless voice, I closed my eyelids which were under the *head gear*.

Part 3

"……'Such a thing wouldn't occur twice', huh……"

Muttering dumbfoundedly, I tried pinching my right cheek, but the scene before my eyes did not disappear.

The *test* space that I was arranged to *dive* into should have been a bright Spring forest. However, there was no soil beneath my feet, no trees in the surrounding and no blue sky overhead.

What existed instead was a completely white space, curved in all directions. The interior of a pure white sphere, such an expression would probably the most adequate one.

Based on my **impression**, it was undoubtedly a VR *space*, but due to this, its extent was hard to grasp. However, if I assume that my *avatar* is the same *size* as I am in the real world, then the diameter of the sphere would probably be three hundred *metres* at the very least……

——My *avatar*?

Rewinding my thoughts a little, I looked at my own body.

In a *FullDive* using the STL, the *avatar* is basically automatically generated from the ≪self-image≫ of the person who was connected. In my previous *dive*, I created the self from the *Sword Art Online* period that received the nickname ≪The Black Swordsman≫. However, as I felt too embarrassed by it, this time I had asked to use a *test*-use *avatar* prepared by *default*, but——

"……This time it's this one, huh……"

I feebly moaned.

It indeed wasn't my self from the SAO period. However, no matter how I looked at it, I was wearing my coat from *ALfheim Online*, which grealy

resembles the black *long coat* I used back then. Even my favourite one-handed sword was equipped on my back. I didn't have a mirror, so I didn't know if it even went as far as reproducing my face, but the feeling of my hairdo was undoubtedly the same as it was for the one I used for my *avatar* in ALO.

Arriving at this point, I had no choice but to accept it. The same ≪quantum *device* space interference≫ as last week had occurred.

Assuming that, will that silver fighter, *Silver Crow*, appear again? However, the feeling of this world was too different. The sphere with a diameter of three hundred *metres* had a outer wall of pure white, which, for some reason, only had curious luminescent *patterns*, but was otherwise thoroughly *clean*. Additionally, the only existing *object* was a small disk that I was standing on.

"Why did this happen again……", I mutter with a sigh mixed in, but at that moment.

"That's what I'd like to ask", a voice, quiet but deep and full of force, resounded behind me.

Without a moment's delay, I tried drawing the sword on my back reflexively as I turned around, but stopped the movement of my right hand during this dangerous moment. This was because I recognised the man standing at the side of the disk.

Under the longish black hair, clever eyes stared fixedly at me. His body, which was several *centimetres* taller than mine, was dressed in a white *jacket* with *emerald green* highlights that seemed like a school uniform. He didn't have anything like a school badge on his chest, but could the school badge be the octagon *emblem* on both his shoulders?

Although I had no memories of the uniform, the sense of deja vu that I harboured for the man's essence wasn't my imagination.

It was indeed ≪him≫. The mysterious NPC……or perhaps player who appeared several days ago in a *campaign quest* in ALO in the role of the *event boss*, the ≪Giant Beli≫. He didn't tell me his name, so I called him thus.

"……We meet again, ≪*No-name-san*≫"

Even though I addressed him like that, the man's expression did not move. It seems that the other party recognised me as well.

"So it's you…… Kirito-kun."

Even as he called out my name, the sharpness in his eyes did not disappear. The reason for that became clear with his following words.

"Does this mean that you got intertwined with my ≪reality≫ this time?"

"……By reality…… do you mean that this is the world you live in, *No-name*-san? This isn't a virtual world?"

I hurriedly asked in return, thinking that the STL couldn't have ended up connecting with a real world. However, the man lightly shook his head.

"No, that's not what I meant. This space is a ≪Five Sense Reproduction-type Virtual *Simulator*≫ that I have been experimenting with. But, of course, the *device* that operates it is installed in the real world. And…… since there's no more concern that I'll be interfering with your *quest*, I'll give you my name as well. I am ≪Shiba Tatsuya≫."

" *Shiba…… Tatsuya*."

I truly had no recollection of hearing the name that I had just repeated. And so, perhaps judging this from my reaction, the eyes of the man named Tatsuya showed a hint of seriousness for a moment.

"……I see, indeed it seems to be an interference accident like the last time. In that case, should I take the same measures to cancel this state, like last time…… I wonder…"

"……Like last time……?"

After once again parroting his words in a mutter, I finally remembered. Last time, in other words, when I had encountered him in ALO, at the critical moment of our sword and spear battle when we simultaneously struck each other, the connection was cut. And, this was the same as when I had fought against *Silver Crow*.

"No, wait. Wasn't the connection cut due to the circuit connecting the two world being unable to endure the burden of our battle at *max speed*?……In other words, it's possible that other methods would also cause the same phenomenon."

"Hmm…… such as?"

Being calmly urged by Tatsuya to continue, I eagerly thought about it. The point is that we should cause a gigantic burden to the world, so…… just as I deliberated up to this point, I recalled the conversation I had with Suguha this morning.

"……!"

I unconsciously materialised the ≪fairy wings≫ on my back and took off from the disk. I did so because I wanted to get some distance, but, with a twitch of his eyebrow, Tatsuya narrowed his eyes and muttered 「……flight magic, huh」.

The next moment, Tatsuya also rose from the disk and *hovered* at the same altitude as me. After signalling him to get some distance, using my *imagination*, I listed a huge numeral. It was a creation borrowed from the STL's operation circuit——a 2048 *bit*, six hundred and seventeen digit cipher key.

"Shiba-san. This numeral is the product of two prime numbers. Try decomposing it into prime numbers with the *device* that operates the *simulator*."

In that case, a gigantic burden would be placed on the *device*…… and consequently, on the circuit connecting the worlds, and it should cancel the state of interference. That's what I thought, but...

The eyes of Shiba Tatsuya, who was floating in the air without even using wings, were tinged with a curious *blue* light.

The six hundred and seventeen digit number that I generated also began shining in white. Bit by bit, all the digits vibrated, and the high pitch and frequency made the world tremble.

————This guy… can't be serious.

————**He is decomposing 2048 *bits* into prime numbers with mental arithmetics**!?

Leaving my surprise behind, the amplitude of the numeral kept increasing to the max. The white light finished dying the spherical wall, and scorched my vision.

Before long, the numeral line began to split right and left little by little.——

Along with the thunderous roar of the world collapsing, the number was decomposed into two gigantic prime numbers.

Shiba Tatsuya's figure started disappearing into the white light. As the infinite space came falling down, I shouted,

"Th-THAT'S IMPOSIBLEEEEE!? IT SHOULD HAVE TAKEN TENS OF YEARS EVEN FOR A *SUPERCOMPUTEEEEEEER*————————!!

On the verge of the world's connection being severed, I felt that I could hear Tatsuya's voice responding to my astonishment.

"……≪Decomposition≫ is my speciality. Let's meet again some day, Kirito-shounen."

(The End)